



Unit 4

Preparing Your Home for an Earthquake

Objectives: At the end of this unit, participants will be able to:

- 1. Identify the most common causes of earthquake-related casualties.*
- 2. List five examples of non-structural earthquake protection changes you can make around the home.*
- 3. Differentiate between earthquake modifications homeowners can make themselves and those that need a licensed contractor.*
- 4. Identify professionals to contact in determining what earthquake changes to make to your home.*
- 5. Discuss the need for mitigation projects in non-traditional seismic risk areas.*

INTRODUCTION

An **earthquake** is a sudden, rapid shaking of the Earth caused by the breaking and shifting of rock beneath the Earth's surface. This shaking can cause buildings and bridges to collapse; disrupt gas, electric, and phone service; and sometimes trigger landslides, avalanches, flash floods, fires, and huge, destructive ocean waves (called tsunamis).

Earthquakes have long been feared as one of nature's most terrifying phenomena. Early in human history, the sudden shaking of the earth and the death and destruction that resulted were seen as mysterious and uncontrollable. In 1969, the

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theory of *plate tectonics* removed the mystery by explaining the origin of earthquakes and showing that they must be accepted as a natural environmental process. (See page G5 for information on the *plate tectonics theory*.)

DANGER ZONES

Earthquakes occur most frequently west of the Rocky Mountains, although historically the most violent earthquakes have occurred in the central United States. **Please note that all 50 states and all U.S. territories are vulnerable to earthquakes.** Forty-one states or territories are at moderate to high risk. Major earthquake risk zones are in these areas:

- the West
- the central Mississippi Valley
- New England
- South Carolina
- Hawaii
- Puerto Rico
- the Virgin Islands

Buildings with foundations resting on unconsolidated landfill, old waterways, or other unstable soil are most at risk. Buildings or trailers and manufactured homes not tied to a reinforced foundation anchored to the ground are also at risk since they can be shaken off their mountings during an earthquake. Earthquakes can occur at anytime of the year.

Did You Know...?

- ✓ Many people think of California as "Earthquake Country," but the state with the most major earthquakes is Alaska. The granddaddy of earthquakes was along the New Madrid Fault in Missouri where a 3-month-long series of quakes in 1811-1812 included three quakes larger than a magnitude of 8. These quakes were felt over 2 million square miles, as far away as Boston. There were few casualties because the country was sparsely settled.
- ✓ The Richter Scale was developed by Charles F. Richter in 1935. It is a logarithmic measurement of the amount of energy released by an earthquake. Earthquakes with a magnitude of at least 4.5 are strong enough to be recorded by sensitive seismographs all over the world. In the United States several thousand shocks of varying sizes occur annually. An important aspect of earthquakes that most people do not realize is that above magnitude 6.7, the shaking does not get any stronger as the earthquake size increases (for observers within 100 miles of the epicenter). The shaking just lasts longer.

CAUSES OF EARTHQUAKE-RELATED CASUALTIES

During an earthquake, the actual movement of the ground is seldom the direct cause of death or injury. Earthquake-related casualties are commonly caused by:

- (1) partial or total building collapse;
- (2) flying glass from broken windows and skylights;
- (3) overturned bookcases, fixtures, and other large furniture and appliances;
- (4) fires from broken chimneys and broken gas lines;
- (5) fallen power lines; and
- (6) an inappropriate or drastic human reaction caused by fear.

What You Can Do *Before* An Earthquake...

EVALUATE THE BUILDING

When selecting a home, most people don't consider evaluating its vulnerability to earthquakes, but we should. There are certain locations and types of buildings that should be avoided altogether. And there are others in which improvements can be made to upgrade earthquake safety. People who rent or lease their homes may not be able or willing to undertake any structural modifications, but the arrangement of interior furnishings can do much to reduce hazards. Information about a particular building's dangers may help you avoid injury during and after an earthquake. If, for example, you know that one exit may be dangerous after an earthquake, you can use another.

Location. Obvious areas to avoid or be very careful about include fault zones, unstable soils, which might experience liquefaction or uneven settling, slide-prone hillsides, and spillways of dams, reservoirs, and storage tanks. Consult a geologist or soils engineer for a thorough evaluation of the geology, or take a look at a geologic map of the area. These maps are often available at the local library or by request from the U.S. Geological Survey.



Whenever you select a home, take a good look at the surrounding area in as many ways as possible. Look around for significant cracks in the earth, streets, retaining walls and driveways. Be aware of the type of industrial facilities, if any, nearby, as well as railroad tracks, freeways, and highways.

Structural characteristics. For earthquake resistance, unreinforced masonry is the most hazardous type of construction, and single story wood frame is the best. Other structural elements to consider are, first, that the frame of the building is connected to the foundation; secondly, that design does not operate *against* earthquake safety. Large expanses of glass may weaken the structure, and complicated architecture involving many exterior corners and wings may reduce the building's ability to flex as a unit. Lateral bracing or shear walls are now

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recommended. Garages that serve as foundations for rooms above them may need additional bracing for earthquake resistance. Heavy roofing materials, such as clay tile, may weaken the structure, and may fall off during ground shaking. Slender stilts for vertical support may not perform well under stress. Chimneys installed before 1960 may not be properly reinforced and tied to the building. Be especially careful about very tall chimneys, which could fall in the direction of an exit.

Non-Structural Preparation

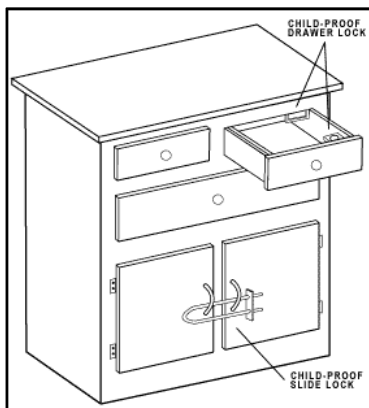
If you aren't sure whether your house is at risk from earthquakes, before investing, check with your local building official, city engineer, or planning and zoning administrator. They can tell you whether you are in an earthquake hazard area. The inspector will also evaluate the earthquake safety of the building by looking at its location and structural characteristics, and make recommendations for any necessary improvements to protect yourself and your house and property from earthquakes.

Earthquake protection can involve a variety of changes to your house and property -- changes that can vary in complexity and cost. You may be able to make some types of changes yourself. But complicated or large-scale changes and those that affect the structure of your house or its electrical wiring and plumbing should be carried out only by a professional contractor licensed to work in your state, county, or city.

Preparing Every Room

The Kitchen.

During an earthquake, shattering glass, spattering chemicals, and falling objects (light fixtures, hanging utensils, and objects sliding off counters, shelves and cupboards) can injure you or members of your family. The following measures will help you prepare your kitchen for an earthquake.



1. Install latches on cabinet doors and drawers so that they will remain closed during an earthquake.

One way to prevent the accidental opening of drawers and cabinet doors is to install latches such as barrel bolts, safety hasps, and childproof locks. Most hardware and home supply stores stock a variety of latches. Catches designed for use in campers are ideal, because they will not open if the cupboard is tilted or shaken. Heavy objects inside your cupboards can lean or fall against the inside of your cabinet doors, and the latches must be strong enough to withstand this pushing. The "passive" latches, which automatically lock when the door is closed, would be best for

families with people who might forget to latch the door. The "child-proof" guards for cupboard doors can also serve as earthquake guards, and these are not visible from the outside. The relatively simple and inexpensive precaution of installing earthquake catches can save you hundreds of dollars, while preventing serious injuries.



Tips

Keep these points in mind when you install latches on drawers and cabinet doors:

- Do not rely on magnetic or pinch-grip catches to hold cabinet doors closed, especially on overhead cabinets and any cabinets that contain heavy, breakable, or dangerous items.
 - Install latches according to the manufacturer's directions. For example, use all of the hardware provided with the latch and do not substitute undersized screws or bolts for those provided.
2. **Store heaviest items on lower shelves of lower cabinets.** Heavy things may break through a cupboard door, but they probably won't hurt anyone if they are at floor level. Don't store heavy and light objects together. Heavy things can tip or slide over and crush lighter objects.
 3. **Put guard rails or "fences" on open shelves so that items can't slide off.** If you want to display fragile things on open shelves, silicon adhesive, or pressure-sensitive, industrial strength Velcro® tape, called "Quake Tape®," or the related Quake Grip® products can be used. Florists' clay is no longer recommended because it deteriorates with age.

For special situations, you may devise your own earthquake safety system. For example, if you want to display your collection of mugs, you might use narrow shelves with a lip and a guardrail made of piano wire or strong fishing line, and separate the mugs by a wooden backboard with indentations for each mug. Or you might install pegs over which each mug could be placed upside down, or "tracks" on the shelf for the base of each mug to slide between. Racks can be purchased or made and after the rack is secured to the shelf, display objects can be placed in the rack.
 4. **Pack breakables for storage.** Delicate crystal, stemware, and china are safest when packed as for moving or shipping: wrapped and packed in a sturdy box and stored on the lower shelf of a cupboard with a secure door. For more accessibility, use racks inside cupboards, anchored to the shelf. Some department stores sell soft quilted caddies with individual compartments for plates, cups and saucers, or stemware. These will offer

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good protection so long as you prevent the whole package from sliding onto the floor.

5. **Secure wall and ceiling fixtures.** Attach light fixtures, clocks, and hanging plants and kitchen utensils to wall studs. These vertical supports, usually 2 x 4s, are spaced 16" apart, inside the walls. Locate one by tapping the wall and listening for a solid rather than a hollow sound. Then measure along the wall to locate the others. Hanging fixtures should be secured to the ceiling joists (the studs in the ceiling) or even better, to a 2 x 4 or other board fastened to the ceiling joists. Fixtures screwed to the plaster, wallboard, or paneling, are more likely to fall, and could take some of the wall or ceiling with them.
6. **When possible, do not store heavy, breakable, or dangerous items (such as insecticides, solvents, and bleach) in overhead cabinets.** (See *Storing Toxic Substances* below.) Storage at floor level in secured cabinets is best. There are plastic caddies for cleaning supplies, which can be used for storing products so that they won't tip over. Dishwasher detergent, drain cleaners, oven cleaners, lighter fluid, and ammonia are some of the most dangerous chemicals. Periodically discard dangerous products you don't often use.
7. **Store extra keys on cup hooks so that you can find them in a hurry.**
8. **Install stoves and other gas appliances with flexible gas lines.**
9. **Block heavy appliances on wheels with doorstops, or remove or lock their wheels to prevent them from rolling.** Cabinetry around a built-in refrigerator will prevent it from moving any direction except forward.

<i>Storing Toxic Substances</i>
<ul style="list-style-type: none">▪ Keep only those chemicals you need on hand. Dispose of old or unwanted chemicals by taking them to an appropriate recycling center.▪ Store ammonia and bleach in different locations. If these liquids mix, they create toxic fumes.▪ Place pesticides, gasoline, paint thinners, etc., on the floor, on a low shelf, or in a locked cabinet that is securely fastened to the wall.▪ If placed on a shelf, install a guardrail to prevent the bottles or containers from slipping off the shelf and breaking or spilling onto the floor.▪ Close lids tightly on all containers.▪ Store gasoline in vapor-proof containers.

Estimated Cost. The cost of adding latches will depend on the type you decide to buy and the number of drawers and cabinet doors you want to secure. Most latches will cost between \$2 and \$5. So, for example, if you do the work yourself, the cost of adding latches to all the cabinets and drawers in a medium-sized kitchen could range from about \$60 to about \$100. If you hire a contractor or handyman to install latches, you will have to pay for time as well as materials.

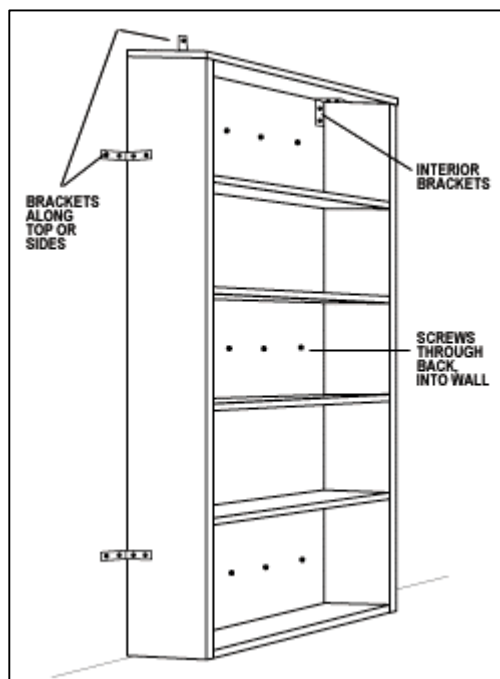
The Bedroom.

In preparing a bedroom for an earthquake, there are three main goals: to prevent objects from falling on the bed, causing injuries; to keep the escape route clear; and to keep needed equipment accessible, (i.e., flashlight, your glasses, your shoes to protect your feet from broken glass, your bathrobe, and, if needed, a few days supply of essential medication.)

- 1. Anchor large pieces of furniture, such as armoires, freestanding closets, dressers, display cases, bookcases and file cabinets, so that they will remain upright during an earthquake. This is something that you can probably do on your own.**

During an earthquake, large pieces of furniture such as tall bookcases and file cabinets can fall on you or members of your family. Toppled furniture can also block exits and prevent you from escaping. Anchoring furniture so that it remains upright not only helps prevent injuries but also helps protect both the furniture and its contents.

You can anchor large pieces of furniture in several ways. Either bolt directly through the back of the furniture into the wall studs or use steel angle brackets. Fallen furnishings could block your escape route, besides causing injury and damage.



Tips

Keep these points in mind when you anchor large pieces of furniture:

- Make sure that all anchoring screws penetrate not just the wall but the studs behind it as well. Screws embedded only in drywall or plaster will pull out. Regardless of the anchoring method you use, the screws should be long enough to extend at least 2 inches into the wall and studs.

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- Before anchoring a bookcase with screws through its back, make sure the back is sturdy enough and that it is securely attached to the sides, top, and bottom. Some bookcases have backs made of very thin materials that are held in place with only small screws or staples that can easily pull out. Those bookcases should be anchored with brackets.
- If you have two or more bookcases or file cabinets that sit next to each other, consider connecting them to one another as well as to the wall. They will be even more stable if you do.
- If possible, move all bookcases, file cabinets, and other large pieces of furniture away from exits so that if they do fall, they won't prevent you from escaping.
- To prevent the contents of your bookcases from falling out, you can install a thin metal or plastic rod, a wood dowel, or even an elastic band across the front of each shelf.

Check the upper shelves of your closets for heavy items, which might slide off. Store your heavy items on the floor or low shelves. Lighter items such as pillows and blankets can be safely stored up high. Cupboards should be closed with earthquake latches.

Estimated Cost. The cost of anchoring a bookcase or file cabinet will depend on its width. In general, if you do the work yourself, you can expect the cost to be approximately \$5 per foot. So, for example, anchoring a 3-foot-wide bookcase will cost you about \$15. This amount covers only the hardware you will have to buy and excludes the cost of any tools you use and the value of your time. If you hire a contractor or handyman to do the work, you will have to pay for time as well as materials.

The Bathroom.

The primary danger in the bathroom during an earthquake is broken glass. Mirrors, toiletries, and medicines can fall and break. More and more personal care products are packaged in plastic now, but liquid medicines, perfume, cologne, and after-shave lotion are sometimes supplied in glass containers. Because you can be cut by broken glass, it is a good idea to follow these guidelines in the bathroom:

- Select products in unbreakable containers, when possible. Use only unbreakable containers in the shower and bathtub.
- Secure the door on your medicine cabinet with a childproof latch.

- Keep only towels and other lightweight and shatterproof items on open shelves, unless they are well secured.
- Store cleaning supplies on the bottom shelf of a low cabinet, closed with an earthquake-proof latch.
- Old shower doors and tub enclosures may be made of regular glass, which could break into sharp, dangerous pieces. Replace these old doors with the newer shower doors and tub enclosures made of *tempered* glass, which shatters into lots of small harmless pieces, or sticky, unbreakable plastic.

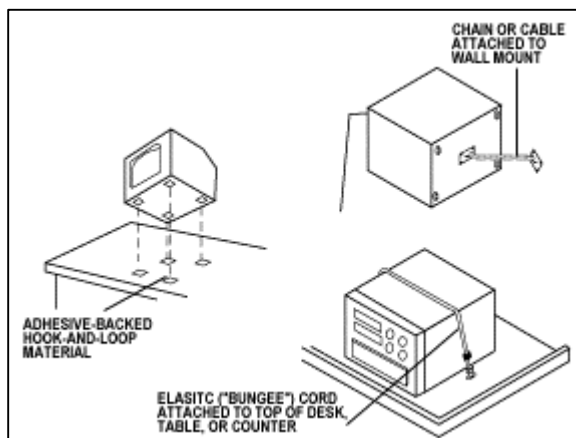
The Living Room, Den, and Dining Room.

1. Restrain personal computers and other small desktop appliances. This is something that you can probably do on your own.

The tremors caused by even minor earthquakes can easily move personal computer systems, stereo systems, television sets, VCRs and other small appliances that typically sit on desks, tables, and countertops. If they fall, they can be damaged beyond repair.

You can protect desktop computers and other small appliances by restraining them in a variety of ways. Some methods, such as using hook-and-loop material (Velcro for example), require no tools. Others, which include using chain, cables, or elastic cord ("bungee" cords for example), will usually require simple hand tools.

Lamps often tip over during an earthquake, because of their high center of gravity. Once they begin to tip or wobble with the action of the earthquake, they often fall over. Select lamps with broad bases and low centers of gravity, and place them on sturdy tables. Vases, art objects, and other small items should not be placed near the edges of tables and can be secured as described.





Tips

Keep these points in mind when you restrain desktop computers and appliances:

- Make sure that the desk or table the appliance sits on is not so light that it can be easily over-turned. If it is, and you can't move the appliance to another location, consider anchoring the desk or table to the floor or wall.
- You can anchor the ends of chains, cables, or elastic cords to either the wall or the surface of the desk, table, or counter using eye-hooks, rings, screws and washers, or other types of mounts.
- If you want to use a wall-anchored chain, cable, or cord, attach it to a closed eye-hook screwed into the wall or to a wall mount (such as a ring or plate) attached with screws. Make sure the eye-hook or screws are long enough to penetrate not just the wall but the studs behind it as well.

Estimated Cost. Restraining a single desktop computer or appliance with one of the methods described will cost you about \$2 to \$10, depending on the amount of hardware required. Using hook-and-loop material will be the cheapest method. Using chain or cable will be the most expensive method but may be necessary for heavy items.

2. Bolt bookcases, entertainment centers, china cabinets, grandfather clocks, and other tall furniture to the studs of the wall behind them by bolting directly through the back of the furniture or by using 3-inch steel angle brackets with two bolts into the furniture, and two bolts into the studs.

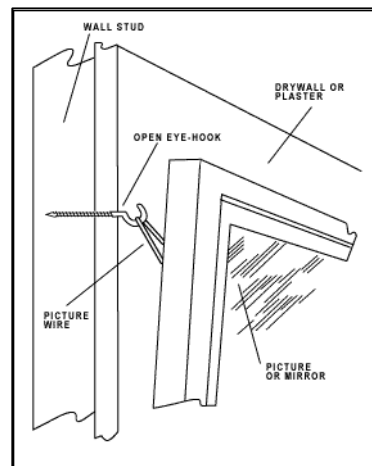
Plumber's tape (perforated steel) can also be used for certain situations. Remember to use oversized steel hardware so that the connection will be strong. Freestanding bookshelves should be bolted to the floor and to ceiling joists or overhead steel bracing. Adjustable shelves, the boards which rest on wall brackets, can be stabilized with clips or wire to connect the board to the bracket.

Bookcases that are anchored or braced at the top are less likely to sway enough to empty onto the floor, but a wire or wooden fence should be added to each shelf of books for protection.

3. Stabilize framed pictures and mirrors so that they will remain in place during an earthquake. This is something that many homeowners can probably do themselves.

During an earthquake, framed pictures and mirrors that are not securely attached to walls can easily fall. Large pictures and mirrors can cause injuries when they fall, and the broken glass that often results increases the potential for injury.

One way to mount framed pictures and mirrors securely is to use long-shanked, open eye-hooks instead of traditional picture hangers. The eye-hooks must be long enough to penetrate the wall stud as well as the drywall or plaster. Eye-hooks used in this way are much less likely to pull out of the wall than picture hooks installed with nails that penetrate only the drywall or plaster. Also, an alternative to running wire across the back of the picture or mirror is to use closed eye-hooks securely screwed into the back of the frame.



Tips

Keep these points in mind when you hang framed pictures or mirrors:

- The number of eye-hooks you need for a picture or mirror will depend on its size and weight. Large pictures and mirrors will be more stable when mounted on two hooks rather than one.
- Make sure that eye-hooks penetrate not just the wall but the studs behind it as well. Eye-hooks embedded only in drywall or plaster are likely to pull out. To be embedded deeply enough, eye-hooks should be at least 12 inches long.
- Regardless of whether you use picture wire or closed eye-hooks on the back of the picture or mirror, make sure the hooks, screws, or other types of mounting hardware are securely attached to the frame. Also, make sure the hardware is strong enough to support the weight of the frame, and that the object is secured to the studs of the wall.
- If possible, don't hang large pictures or mirrors in places where they are more likely to fall on someone, such as over beds, chairs, or couches.

Estimated Cost. The cost of mounting a picture or mirror with eye-hooks will depend on its size and weight. In general, for a large picture or mirror that requires two eye-hooks, you can expect the cost to be approximately \$3 to \$5.

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This amount covers only the hardware you will have to buy, not any tools you use or the value of your time. If you hire a contractor or handyman to do the work, you will have to pay for time as well as materials.

4. **Securely attach chandeliers and other hanging objects to the ceiling joists or to a strong board attached to the top of the joists.**

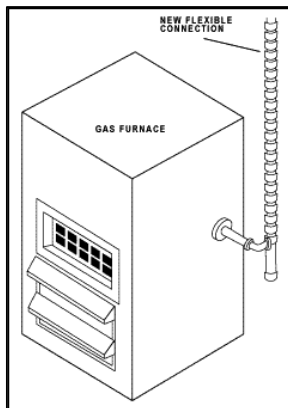
The Laundry Room, Utility Room, Garage, and Workshop.

1. Secure your water heater.

With its high center of gravity, the home appliance most vulnerable to earthquake damage is the standard water heater. Although modern water heaters have been designed to be a bit more steady than the early models, these large water-filled cylinders are still likely to "walk" or even tip during an earthquake. If this happens, the utility lines may be disconnected, causing gas or water leakage, or electrical shorts, fires, or explosions. And if it does tip over, you could lose one of your best sources of water for the period following the earthquake. Here's how to prevent the water heater from moving or tipping over:

- Wrap steel plumber's tape around the entire heater at least twice. Then secure the tape to two different wall studs with big 2-inch or longer lag screws. For added security, place blocking between the heater and the wall to prevent movement. Install a plywood "shelf" behind the heater, cut to fit the water heater's circular shape, or a 2 x 4 or similar board behind the heater to prevent it from tipping.

2. Install flexible gas and water connectors. This is something that only a licensed contractor should do.



The figure shows a flexible connection pipe installed on 2 gas furnaces.

Because most gas and water lines are rigid, they can be torn from their connection points during an earthquake. The results could include not only serious damage to your house but also injury to you and members of your family. A broken gas line is especially serious because of the potential for a fire or even an explosion.

One way to prevent broken gas and water lines is to have flexible connection pipes installed between appliances and their supply lines. *The figure shows a flexible connection installed on a gas furnace.* The same method can be used for other appliances, such as a hot water heater, clothes dryer, or stove. A licensed contractor can usually do this for you easily.

- 3. Have a plumber drain the heater every year, or learn how to do it yourself.** The water in the tank can then be used to drink in an emergency.



Tips

Keep these points in mind when you have flexible connections installed:

- Changes to the gas lines and plumbing in your house must be done by a licensed contractor, who will ensure that the work is done correctly and according to all applicable codes. This is important for your safety.
- A flexible connection will help protect against a small amount of movement but is not designed to function when the appliance it is connected to moves extensively or falls. So you should also consider anchoring the appliance to the floor or wall.

Estimated Cost. Having a flexible connection installed on a furnace or other large appliance will cost you about \$75.

- 4. Carefully store flammable, poisonous, and explosive substances.** This may prevent injury, fire, and other damage. Store the following in unbreakable, clearly identified containers in low cupboards with earthquake-proof latches: paint, gasoline, paint thinner, bleach, ammonia, pesticides, herbicides and other dangerous products. Volatile substances—gasoline, paint, or lacquer thinner, etc.—should not be stored in a room with a pilot light. They should be stored in a well-ventilated room equipped with a fire extinguisher. In workshops and work areas, install fences or doors on open shelves. If you keep lumber or firewood, stack it in a sturdy crib no higher than waist level.

The Windows.

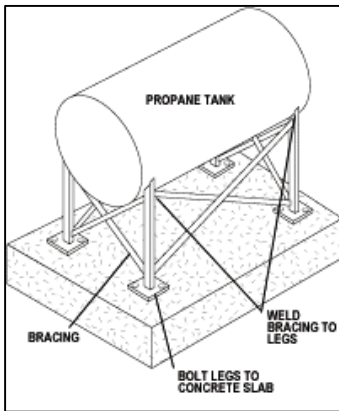
Large windows, particularly next to exits and beds or other places where people spend a lot of time, can be dangerous if they break during an earthquake. There are two options:

- tempered glass, which breaks into tiny rounded pieces, or
- shatter-resistant film, a plastic film applied to glass.

The film is less expensive than replacing the glass, but it must be installed by an expert. The shatter-resistant film is similar to the film that may tint windows or make them reflective, but the plastic and the adhesive is stronger so that if the window breaks, the plastic holds the pieces together.

Earthquake Protection for Other Items in the Home.

1. Anchor and brace propane tanks and gas cylinders. These are things that skilled homeowners can probably do on their own.



During earthquakes, propane tanks can break free of their supporting legs. When a tank falls, there is always a danger of a fire or an explosion. Even when a tank remains on its legs, its supply line can be ruptured. Escaping gas can then cause a fire. Similar problems can occur with smaller, compressed gas cylinders, which are often stored inside a house or garage.

One way to prevent damage to propane tanks and compressed gas cylinders is to anchor and brace them securely. The figure shows how the legs of a propane tank can be braced and anchored. Using a flexible connection on the supply line will help reduce the likelihood of a leak.

Compressed gas cylinders, because they have to be periodically replaced, cannot be permanently anchored. But you can use chains to attach them to a wall so that they will remain upright.



Tips

Keep these points in mind when you anchor and brace propane tanks or compressed gas cylinders:

- Before you alter your propane tank in any way, make sure that the tank is your property and not rented from the propane supplier. Before welding new bracing to the tank legs, you must remove the gas from the tank. You should also check with your propane supplier to find out whether additional precautions are necessary.
- Clear the area around the propane tank to ensure that there are no tall or heavy objects that could fall on the tank or rupture the supply line.
- Keep a wrench near the shutoff valve and make sure the members of your family know how to turn off the supply line if they smell a gas leak. On larger tanks, such as farm tanks, consider installing a seismic shutoff valve that will automatically turn off the gas during an earthquake.
- Provide a flexible connection between the propane tank and the supply line and where the supply line enters the house. But keep in mind that adding a flexible connection to a propane tank line should be done by a licensed contractor, who will ensure that the work is done correctly and according to all applicable codes. This is important for your safety.

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- To attach a compressed gas cylinder to a wall, use two lengths of chain around the cylinder -- one just below the top of the cylinder and one just above the bottom. The chains should be attached to eye hooks that are screwed into the wall. In wood-frame walls, the eye hooks must be long enough to penetrate not just the wall but the studs behind it as well. In concrete or masonry block walls, the eye hooks should be installed with expansion anchors or molly bolts.

Estimated Cost. Bracing and anchoring a propane tank will cost about \$250. Having flexible connections installed on the tank and at the house will cost about \$75. Attaching one gas cylinder to the wall will cost about \$50.

For more information on how to use these tips or for configurations other than the ones discussed above, consult your stove or propane vendor, local office of emergency services and/or local fire department.

2. Secure wood burning stoves to wall or floor studs. Make sure you have a fire extinguisher close at hand.

Freestanding wood burning stoves pose an additional risk in an earthquake. Heavy objects such as stoves are actually more likely to move during strong ground shaking than lighter objects. Fire codes leave the stoves unsupported on all four sides and vulnerable to sliding or overturning in an earthquake. If the stove were to tip and/or separate from the stovepipe, cinders or sparks might easily cause a fire in the home.



In order to reduce the potential fire hazard following an earthquake, the stove should be anchored to the floor and stovepipe sections secured. It is important that the seismic anchors or braces do not conduct heat from the stove. Although there are many types of stoves in use, the following recommendations can be used for common installations:

- Stoves resting on brick hearth can be anchored using bricks and mortar.
- Mobile home approved units come with pre-drilled holes in the pedestals or legs and can be safely anchored to the underlying floor framing.
- Those resting on concrete slab-on-grade can be anchored directly to the concrete.
- Stovepipe should be anchored to the flue exit and each of the stovepipe segments should be secured together.

Structural Preparation

Determining the Safety of Your Home

Next to loss of life, the loss of your home will be the greatest catastrophe to occur in an earthquake. Engineers learn more about how to build and reinforce existing buildings after every earthquake. Even though your home was built to seismic specifications several years ago, there may be things you can do now to strengthen it. If you had retrofitting done several years ago, you should check current standards and update the work.

Most people are safe at home if they live in a well-braced wood-frame building of one or two stories. These buildings are unlikely to collapse completely during earthquakes. Common damage in these structures is light cracking of interior walls or cracking of brick.

Older wooden structures can fail at or near ground level if not adequately bolted to the foundation, or if the pier-and-post foundation or short cripple walls (often found between the foundation and the first floor) are not adequately braced. Your local community planning or building inspection office has information on adding foundation bolts and bracing cripple walls. (*See section #1 below.*) Correcting these problems will drastically reduce earthquake risk in older homes.

Mobile Homes. Special considerations are needed for mobile homes and modular buildings not attached to permanent foundations. These structures can slide off their foundation if not properly secured to resist horizontal motion.

Special earthquake stabilizing devices for mobile homes are available. Check with earthquake retrofit specialists in your area. These devices have proved to be effective in preventing or minimizing damage in several recent earthquakes.

Structural engineers advise that four precautions will improve the earthquake readiness of a mobile home:

1. Keep the axle, wheels, and inflated tires on the unit.
2. Reduce interior hazards in the same way as for conventional housing.
3. Install an earthquake safety device to keep the unit from falling off its supports.
4. Install an automatic gas shutoff valve.

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It is difficult to make suggestions which will be applicable to every situation. The best thing to do is to read this material, acquaint yourself with your building, and consult with a licensed engineer or contractor who specializes in earthquake retrofitting. Retrofitting costs vary a great deal depending on what needs to be done. However, the expense of retrofitting is nothing compared to repairing or replacing your house. One estimate is that the cost of picking up a house and setting it back on its foundation will be 23 times greater than the cost of preventative retrofitting!

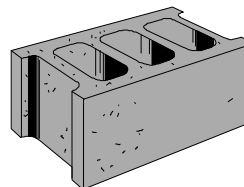
The most important things you can do to mitigate the effects of an earthquake are:

- 1) to maintain your home and ensure its structural integrity by having regular inspections for pests and decay, and
- 2) to improve the building's resistance to earthquake damage by keeping the retrofitting up with seismic standards.

Following are earthquake protection steps to be applied to the foundation of your home and to the chimney.

Foundation

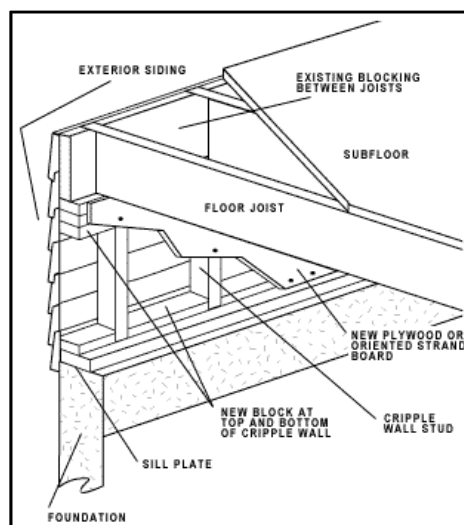
- ❖ Be sure that you have good strong foundation.
- ❖ Check to see that the mudsill is not rotted.
- ❖ The house should be securely fastened to the foundation with expansion bolts. If your home was built before 1950, it probably does not have bolts securing the wood structure to the concrete foundation. There should be a bolt at each end of a section of mudsill and one every 4 feet in between.



1. Brace Cripple Walls.

For a house built on a cripple wall foundation, brace the cripple wall to increase structural stability and reduce earthquake damage. This is something that skilled homeowners can probably do on their own, provided they obtain any necessary permits.

A cripple wall is a short wall that rests on the foundation and supports the floor and exterior walls. Even if a foundation is bolted, it is possible for the house to collapse in this area if the connection is not made between the mudsill, studs and the plate. A shear wall braces the connection between the mudsill, studs and plate.



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If the cripple wall is not braced, it can shift during an earthquake. When this occurs, there is a greater likelihood that your house will be severely damaged and that you and members of your family will be injured.

If your house is built on cripple walls, **bracing the cripple walls** is one way to increase its stability and reduce earthquake damage. In this method, horizontal blocking that consists of 2 x 4-inch boards is added between the vertical studs at the top and bottom of the cripple wall and, if necessary, at other locations between the studs. New vertical studs can also be added if necessary. *Plywood or oriented strand board is then nailed to the interior face of the cripple wall. Also, nails are added through the existing blocking between floor joists to ensure that the floor is securely attached to the cripple wall.

***Note:**

- Plywood panels (5/8 inch) are nailed with 10d common nails every 4 inches around the horizontal members and every 6 inches down the studs.
- The shear wall panels should be installed around the perimeter of the house. They are most needed at the corners – 8 feet from each corner in a one-story house, 16 feet in each direction in a two-story house.



Tips

Keep these points in mind when you brace cripple walls:

- Check with your local building officials to see whether you need a permit to do this work.



- Before adding any bracing, check to see whether the sill plate below the cripple wall is bolted or otherwise anchored to the top of the foundation.

If it is not, you should consider having bolts or anchors added. Any anchoring of the sill plate should be done before you add bracing. For more information, refer to section number 2 below on *Bolting Sill Plates to Foundation*.

Estimated Cost. Bracing a 2-foot-high cripple wall will cost you about \$1.50 per linear foot of wall. For example, a house measuring 60 feet by 30 feet will have a perimeter of 180 feet. So the cost for that house would be about \$270. This figure covers only the materials you will have to buy and excludes the cost of any tools you use, building permit fees, and the value of your time. This figure also excludes the cost of having a contractor anchor your sill plates. Also, bracing higher cripple walls may require more lumber and therefore may be more expensive.

2. Bolt the Sill Plates to Foundation.

Bolting the sill plates of your house to its foundation will increase structural stability. This is something that only a licensed contractor should do.

The sill plate of a house rests directly on top of the foundation. (This figure shows the sill plate for a house built on a cripple wall and crawl space foundation, a type of construction that is especially susceptible to earthquake damage.) If the sill plate is not securely anchored, an earthquake can cause it to shift on the foundation. When this occurs, there is a greater potential for severe damage as well as injury to you and members of your family.

To increase the stability of your house and reduce earthquake damage, have the sill plate bolted or otherwise anchored to the foundation. In the method shown in the figure, bolts long enough to pass through the sill plate and penetrate several inches into the foundation are installed every few feet along the base of the exterior walls. This method is not limited to cripple wall construction; it can also be used for a house built on a basement or slab-on-grade foundation or on another type of crawl space foundation.



Tips

Keep these points in mind when you have the sill plates bolted to the foundation:

- Modifications to the foundation of your house must be done by a licensed contractor, who will ensure that the work is done correctly and according to all applicable codes. This is important for your safety.

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- Bolts are usually installed no more than 6 feet apart. The work involved is likely to be extensive and may require that portions of the walls or floor be cut away temporarily.
- Your contractor may be able to recommend an alternative anchoring method based on other approved fasteners or connectors that can be installed with fewer changes to your house and less work.
- If your house is built on cripple walls, you should consider bracing them after the sill plates are bolted. For more information, refer to the section number 1 above titled *Brace Cripple Walls*.

Estimated Cost. Having a contractor bolt the sill plates to the foundation will cost you about \$50 to \$75 per bolt, depending on the type of foundation you have. For example, a house measuring 60 feet by 30 feet, will have a perimeter of 180 feet and would therefore require a minimum of 30 bolts (if the bolts are placed no more than 6 feet apart). So the cost for that house would be about \$1,500 to \$2,250.

Chimney

- ❖ Reinforce the ceiling surrounding the chimney with $\frac{3}{4}$ -inch plywood nailed to ceiling joists.
- ❖ Do not brace the chimney to the roof. Rods connecting the chimney to the roof cause the chimney to fall through the ceiling as a unit which is far more damaging than if the chimney merely cracks and falls in pieces.
- ❖ Be sure to have the chimney checked, and repaired if needed, before using it after an earthquake.

You may need to do additional structural work to protect your house such as blocking between the joists, using additional hold-downs on corners of the building, etc. Please consult with a structural engineer for specifics on your home.

Who to Contact *Before* An Earthquake Strikes...

If you have earthquake damage, NOW is the time to strengthen your home correctly. If your home escaped damage, NOW is the time to evaluate your home and install strengthening measures -- before you forget, and before the next earthquake. Contact a licensed professional about making the necessary changes to your home or office. Contact your local building department to modify details to fit local building codes.

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How do you locate professionals to advise you on the resistance of your building to earthquake shaking? Who should perform the needed construction?

Civil and Structural Engineers Architects	☞ are trained to provide information about structures.
Geologists Foundation Engineers Geotechnical Engineers	☞ are trained and licensed to evaluate soil conditions and recommend appropriate action.
A Contractor	☞ has to implement the detailed plans and specifications prepared by an architect or engineer.

A good place to start is to call a professional organization and ask about the types of work that might be required; how to select an engineer, geologist, or architect; and a list of members in your area. Contact several firms or individuals to determine whether they do the types of work you need. Make sure the firm has the necessary licenses and has experience in strengthening structures to resist earthquake shaking. Recognize the quality of the advice given and the work performed, as well as the price you pay, may depend on the care you take in making your selection.

Become informed. Even if you do not understand the technical details, ask enough questions to understand the concepts and relative importance of the issues involved. You have a right to understand what needs to be done and why.

State and federal agencies do not inspect individual buildings. Your local building department may be willing to inspect your building, but they are not authorized to recommend actions to be taken.

WHAT TO DO IN THE HOME *AFTER* AN EARTHQUAKE:

1. **Check for injuries.** Do not move a seriously injured person unless they are in immediate danger of further injuries.
2. **Check for hazards.**
 - *Fire or fire hazards.*
 - *Gas leaks.* Shut off the main gas valve only if a leak is suspected or identified by the odor of natural gas. Wait for the gas company to turn it back on once the damage is repaired.
 - *Damaged electrical wiring.* Shut off power at the control box.

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- *Downed or damaged utility lines.* Stay away from downed lines, even if power appears to be off.
- *Fallen objects in closets and cupboards.* Displaced objects may fall when you open the door.
- *Downed or damaged chimneys.* Approach chimneys with caution. They may be weakened and could topple during an aftershock.
- *Your telephone.* Make sure each phone is on its receiver. Telephones off the hook tie up the telephone network unnecessarily.



3. **Clean up.** Potentially harmful materials and/or medicines may have spilled.
4. **Anticipate tsunamis.** Pronounced soo-náh-mee, they are strong ocean waves generated from earthquakes. If you live along the coast, be alert for news of tsunami warnings issued by the federal government's Tsunami Warning Center. *If an earthquake is centered nearby, there will not be time to issue a warning.* If you experience a strong earthquake that lasts a very long time, move to higher ground or go to the upper floors of a building as soon as you are able and stay there until the authorities issue an *all clear*.
5. **Expect aftershocks.** Most of these are smaller than the main earthquake. Some may be large enough to do additional damage to weakened structures.

What To Do *Right Now* To Prepare:

PROTECT YOURSELF

1. **Practice *drop, cover, and hold* drills at home with your family and at work.**
Injuries and deaths during earthquakes are caused by falling objects and collapsing structures. Show children safe areas to drop and cover. Practice counting how many seconds your *test earthquake* lasts. This will help you keep calm when a real earthquake strikes.
2. **Develop an earthquake plan.**
If an earthquake hits during the day, family members may be separated for hours or even days. Your local chapter of the American Red Cross can help you develop a plan at home, at work, and in your neighborhood. A family plan should include:
 - A safe place where your family can reunite after the earthquake. Transportation may be disrupted. Select alternate meeting places near work or schools.

- Designation of an out-of-the-area telephone contact. Completing local telephone calls may be difficult. It will probably be easier to telephone someone out of the earthquake area. Select a relative or friend to act as a clearing house for information about your family. All family members should call this contact to report their condition and location. Make sure family members carry this number with them at all times. Other friends and relatives should know this number too.
- Discuss the plan with all family members. Discuss with children what will happen to them if an earthquake occurs while they are at school.

3. Know the following:

- What to do during and after an earthquake. (*Resources for this information are listed on page 4 of this manual.*)
- The safest places in your home. They should be away from heavy furniture or appliances, wood stoves, fireplaces, and large panes of glass, pictures, or mirrors.
- Where your gas, electric, and water main shutoffs are and how to turn each off. Now is the time to buy a special wrench that fits your gas turnoff valve and to fasten it next to the valve. Remember, turn off the utilities only if you suspect the lines are damaged, if you smell gas, or if you are instructed to do so. *If you turn the gas off, you must contact your utility company to turn it back on.*
- How to fight fires, rescue people trapped under debris, provide first aid, find help for dire emergencies, and assist others, especially the fragile elderly or disabled. Ask your local American Red Cross office or County Mental Health Department for more information.
- The policy of your local school concerning release of children after an earthquake. Arrange with neighbors to watch out for your family and property in case you are not home.

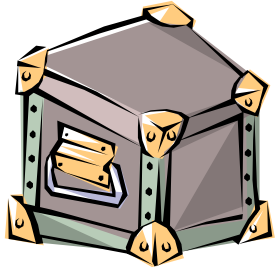
4. Store emergency supplies.

- After a major earthquake, medical aid, transportation, water, electricity, and communication may be unavailable or severely restricted for days or weeks. Be prepared to take care of yourself,

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your family, and your neighbors for at least three days -- longer if you live in a remote area.

- At home, at work, and in your car, store



*a flashlight
batteries
an A-B-C-rated fire extinguisher
a battery-operated radio and extra batteries
a first-aid kit and manual
at least one gallon of water per person per day
emergency food
warm clothes
sturdy shoes
gloves
essential medicines*

- Make sure emergency supplies are located in a safe and readily available place.
- Make sure everyone in your family knows where these supplies are and how to use them.
- Take a course in first aid from your local chapter of the American Red Cross.
- Include pets in your planning. Plan for their food and water supplies for at least three days.
- Make arrangements with a neighbor to care for your pet in the event you are unable to get home.

5. Find Out More.

- Look at the first aid and survival guide in the introductory pages of your telephone book.
- Go to your local library. Ask the librarian for reference materials listed in this manual.
- Ask your city or county Office of Emergency Services or your local American Red Cross for pamphlets on preparedness and survival. Invite a speaker to talk to your club or organization about earthquake preparedness.

Earthquake Insurance

As we have seen in this unit, earthquakes can do a great deal of damage to your home and personal possessions and, at its worst, financially devastate a family. Aside from being physically prepared for the earthquake, homeowners should also be financially prepared. One way to be financially prepared for an earthquake is to purchase earthquake insurance. Be aware that earthquake insurance, like flood insurance, is not covered under a standard homeowners policy. You may have to add a special rider to protect your home from damage caused by an earthquake.

The vast majority of people don't buy earthquake insurance. Some believe that if a disastrous earthquake strikes, the area would probably be declared a federal disaster area making them eligible for federal disaster benefits. However, in most cases, disaster relief comes in the form of low-interest loans.

To help you decide whether or not you need earthquake insurance, consider the following:

- What is the likelihood of an earthquake occurring in your area?
- Is your home close to an active fault?
- What is the nature of the ground or soil under your home? (*You're at higher risk if the soil is sandy or loose or if you live on a fill area.*)
- Is your home a single-story, two-story, or multi-level?
- Are the walls and foundations properly braced?
- Is your home of wood-frame construction, stone or brick? (*Bricks or rocks covering the outside of a building are usually not covered unless you pay a higher premium.*)
- How old is your home? Older homes are at higher risks for damages.

Should you decide to purchase earthquake insurance, remember that you should buy enough to cover the costs of totally rebuilding your home. The amount of insurance you buy should be based on replacement and reconstruction costs, not the fair market value of your property or possessions. The earthquake rider usually comes with a deductible, ranging from 10 to 20 percent of the amount covered. This means that a policy covering a house for \$100,000 and contents for \$25,000 with a 10 percent deductible, requires the policyholder to pay the first 10,000 of damage to the house and the first 2,500 of damage to contents. Your premiums will depend on where you live (premiums vary according to proximity to fault lines), the type of home you have (wood or brick), and of course the amount of the deductible. Talk to your insurance agent about your coverage.

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Tips

Keep these points in mind when purchasing insurance:

- Keep your insurance up-to-date: Review your homeowners policy on an annual basis. Check to make sure you have coverage to rebuild your home if it is completely destroyed. Check with local contractors to get an idea of rebuilding costs.
- Inventory your home. Write down serial numbers and take photographs or videotapes. It may be difficult to remember everything in your home after disaster strikes.
- Store documents safely. Keep copies of both your policy and your home's inventory in a safe deposit box or with out-of-town family or friends. If this is not possible, storing documents in a fireproof box in your home may be the best alternative.

Earthquake Hazard Hunt

Below is a list of mitigation practices to accomplish in your home before an earthquake occurs. The task is listed, along with space to record the date you complete each task.

1. Check your water heater. Securely fasten to the wall studs with screws and plumber's tape.

DATE TO DO _____

2. Identify top-heavy, freestanding furniture that could topple in an earthquake, such as bookcases and China cabinets.

Secure to wall. **DATE TO DO** _____

3. Identify heavy or breakable objects on high shelves or in cabinets.

Securely fasten or move. **DATE TO DO** _____

4. Identify electronic equipment (stereos, computers, etc.) and appliances (microwave, toasters, etc.) that might slide off their cabinets.

Secure with industrial strength Velcro or provide a restraining edge on the cabinet or shelf.

DATE TO DO _____

2. Identify hanging plants, especially those in heavy baskets, and hanging lights that are near windows.

Secure, move or fasten down.

DATE TO DO _____

3. Identify mirrors, heavily framed pictures, etc., that are placed over beds, couches, and chairs.

Relocate or securely mount them.

DATE TO DO _____

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4. Identify appliances that could move enough to rupture gas or electrical connection.

Securely fasten these objects.

DATE TO DO _____

5. Check appliances and the water heater to make sure they are connected to the fuel source with flexible lines.

Install flexible connectors on gas appliances and the water heater.

DATE TO DO _____

6. Identify latches on kitchen and bathroom cabinets that will not hold the door closed during heavy shaking.

Install more secure latches or hooks.

DATE TO DO _____

7. Inspect the foundation of our house. If you house is not securely bolted, and shear walled, contact a resource person.

DATE TO DO _____

8. Check your chimney and roof for loose tiles and bricks.

If there is work to do, contact a resource person.

DATE TO DO _____

9. Identify poisons, toxins, or solvents in breakable containers that are located in high or dangerous locations.

Dispose of and/or rearrange.

DATE TO DO _____



Unit Review

Circle the correct response. Answers may be found on page _____.

1. One way to increase the stability of your house and reduce earthquake damage is to:
 - a) install latches on windows and doors.
 - b) bolt or anchor the sill plate to the foundation of the house.
 - c) not hang pictures on the wall over the bed or sofa.
 - d) move the house from its present location.
2. The best way to prevent damage to personal computers and other small appliances during an earthquake is to:
 - a) make sure they sit on a heavy desk or table.
 - b) make sure PC's and small appliances are turned off during an earthquake.
 - c) restrain them with Velcro or bungee cords.
 - d) store the appliances on the floor of the closet.
3. A house built on a cripple wall foundation means:
 - a) The house is inexpensive, but sturdy.
 - b) The house will likely not be damaged during an earthquake.
 - c) You will pay thousands of dollars to prepare the house for an earthquake.
 - d) The house is built on a short wall that rests on the foundation and supports the floor and exterior walls.
4. Which of the following is not a reason to install latches on cabinet doors and drawers before an earthquake?
 - a) Stored materials (e.g., insecticides, solvents, and bleach) can spill out and damage floors and floor coverings.
 - b) Objects can fall from overhead cabinets and injure you or members of your family.
 - c) You want to keep clean-up to a minimum following the earthquake event and picking up items off the floor will be extra work.
 - d) Latches can be easily installed and removed.
5. A broken gas line during an earthquake is serious because of the potential for a fire or explosion. How do you prevent broken gas and water lines during an earthquake?
 - a) Install flexible connection pipes between appliances and their supply lines.
 - b) Anchor the appliances to the floor or wall before the earthquake.
 - c) Disconnect gas and water lines.
 - d) Have a contractor inspect the gas and water lines before an earthquake.
6. As discussed in this unit, which of the following should not be braced in trying to prevent earthquake damage?
 - a) Roof
 - b) Ceiling
 - c) Cripple Wall
 - d) Chimney